Fermilab SRF ILC R&D Plan

Shekhar Mishra

Fermilab

7/18/05

Fermilab R&D Goals

- Fermilab ILC R&D is focused on addressing the key ILC design and technical issues, cost reduction and US industrial involvement in ILC.
- These goals are aligned with the R&D that will be needed to address the BCD.
- They are designed to establish the viability of all technical components addressing TRC Ranked R&D goals, costs, engineering designs to enable “early” decision (by 2010) and to position the US (and Fermilab) to host the ILC.
- The main thrust of the Fermilab ILC R&D is to establish US technical capabilities in the Superconducting Radio Frequency Cavity and Cryomodule technology.
  - 1) Cavity technology development in the US to routinely achieve $\geq$ 35 MV/m and Q ~0.5-1e10,
  - 2) ILC Cryomodule design, fabrication and cost reduction
  - 3) Fully tested basic building blocks of the Main Linac, Evaluate the reliabilities issues.
  - 4) Accelerator design issues in the Main Linac, Damping Ring and Machine Detector Interface
  - 5) Development of an ILC site near Fermilab.
- While focused on the long term goals for ILC design and construction, Fermilab will also work with the GDE in development of the Reference Design Report, taking responsibilities for the chapters on Main Linac and US Site, by the end of FY06.

ILC R&D at Fermilab
FY06 Goals

- Baseline Configuration Document and Reference Design Report
- Accelerator design
  - Main Linac
  - Damping Ring
  - Machine Detector Interface
- Fermilab site development
- Cavity Fabrication and Processing Technology
  - Development of the BCP parameter at Cornell (25 MV/m)
  - Development of the EP parameters at Jlab (35 MV/m)
  - 25 MV/m cavities fabricated and Tested (VDT/HDT) with BCP using US industrial production and FNAL/ANL processing.
  - Study and Develop infrastructure for EP at FNAL/ANL
- First US assembled cryomodule Type III+ to study design and cost reduction issues
- International collaboration on the Design of an ILC Cryomodule
- Develop industrial base in US for Main Linac Components.

ILC Accelerator Technology R&D

- Energy R1: The feasibility demonstration for the ILC requires that a cryomodule be assembled and tested at the design gradient of 35 MV/m. This test should prove that the quench rates and breakdowns, including couplers, are commensurate with the operating expectations. It should be shown that dark currents at the design gradient are manageable, which means several cavities should be assembled together in a cryomodule.
  - Cavity technology development in the US to routinely achieve ≥ 35 MV/m and Q ~0.5-1e10,
- Energy R2: To finalize the design choices and evaluate the reliability issues it is important to fully test the basic building block of the linac. This means several cryomodules installed in their future machine environment, with all auxiliaries running, like pumps, controls etc. This test should as much as possible simulate the realistic machine operating conditions, with the proposed klystron, power distribution system and with beam. The cavities must be equipped with their final HOM couplers. The cavity relative alignment must be shown to be within requirements. The cryomodules must be run at or above their nominal field for long enough periods to realistically evaluate their quench and breakdown rates.
  - ILC Cryomodule design, fabrication and cost reduction
  - Fully tested basic building blocks of the Main Linac with beam, Evaluate the reliabilities issues.

US-ILC Main Linac Responsibilities

- ILC Studies will be coordinated with GDE.
- In US Fermilab has the responsibility of the Main Linac superconducting part and RF Control.
  - We are coordinating this work with the collaborating institutions.
- In US SLAC has the responsibility of the Main Linac RF power.
  - We are developing modulator and purchasing klystron to get started based on existing design.
  - SLAC is doing R&D and will be taking a lead in this for ILC.

Fermilab ILC SRF R&D Plans

- Upgrade infrastructures at Cornell (BCP) and Jlab (EP) to process cavities produced in 1st phase.
- Develop BCP and EP processing parameters to achieve 35 MV/m using Cornell and Jlab facilities.
- Develop infrastructure to assemble cavity strings and cryomodules at Fermilab
- First US assembled cryomodule Type III+ using BCP and EP cavities from Cornell and Jlab processing.
- Commission the FNAL/ANL BCP facility to process cavities produced in 2nd Phase.
- Commission the Single Cavity Horizontal Test Stand at Fermilab.
- 25 MV/m cavities fabricated and Tested (Vertical/Horizontal) in USA with BCP at FNAL/ANL.
- Develop infrastructure for EP at FNAL/ANL
- Design and construction of a Single Cavity Vertical Test Stand at Fermilab
- Design and initial fabrication parts for an ILC Cryomodule (4th generation)
- Develop High Power Test Facility Infrastructure to cool down, power and test with beam

ILC Cavities Plan FY05-06

- Four cavities from DESY to get the tooling and processing infrastructure started at Cornell and Jlab ASAP.
- One cavity from DESY (Capture Cavity) to get the Meson infrastructure up and running.
- 4 cavities each from (AES and ACCEL). These cavities will be processed at Cornell and Jlab. The goal is to develop BCP and EP processing parameters, train people and get industry involved.
- US-Japan agreement to provide 4 processed and VDT tested cavities.
- 8 Dressed cavities from DESY. These cavities will be electro polished, vertical test, Dressed and horizontally tested and sealed. (This is in exchange of 3.9 GHz cavities and cryomodule Fermilab is fabricating for DESY.)
- US Industry to fabricate cavities for US production and tight loop processing.
- Develop Reentrant cavity and Single crystal (Standard Design) cavities.

ILC Cavity Processing

- 4 DESY cavities will be used to develop tooling, initial processing etc. at Cornell, Jlab and ANL for the processing of 1.3 GHz cavities.
- In the Phase I the plan is
  - Upgrade infrastructures at Cornell (BCP) and Jlab (EP) to process and vertical test 1.3 GHz cavities.
  - Use the Cornell BCP and VDT facility to develop BCP parameters (25 MV/m).
  - Use the Jlab EP and VDT facility to develop EP parameters (35 MV/m).
  - Develop HPR, BCP and EP facility at FNAL/ANL

Cavity Processing

- In Phase 2 (Tight Loop Production and Processing)
  - Use Cavity produces by industry
  - Process cavity at FNAL/ANL BCP
  - Study development of an EP facility at FNAL/ANL
    - Discussion has taken place between Fermilab, LANL, ANL and KEK to develop a EP facility for ILC. This will be done in collaboration with DESY and Jlab.

At the end of this phase we will have two facilities each in US for BCP and EP Processing capable of producing 35 MV/m cavities.

1) BCP facilities at Cornell and ANL/FNAL
2) EP facilities at Jlab and ANL/FNAL

Deliverable: Cavity fabrication technology to reliably and cost effectively produce cavities with gradient $\geq$ 35 MV/m.

Infrastructure for ILC Cavity

- Infrastructure at Cornell and Jlab needs upgrade to process the 1.3 GHz cavities.
- Fermilab is working on installation and commissioning of the BCP facility at ANL (FY06)
- Fermilab has purchased a clean room for these cavities and its dressing for the Horizontal test. This is part of the Cryomodule Assembly Facility.
- Fermilab is building a horizontal test stand and plans to build a vertical test stand. Need cryogenic, RF Power, controls etc.
- We are working on a design study to develop the EP facility at ANL/FNAL.

Cryomodule Design

- Fermilab has started a global discussion on the ILC Cryomodule design. (DESY, INFN, KEK and Fermilab)
- The current design does not have all the knowledge from the cryomodule fabrication at DESY/INFN.
- Also there exists a general view is that current design needs to evolve.
- Fermilab has been in discussion with two companies who plans to participate in cryomodule fabrication with a view of fabricating it at there factory at a later date.
- Fermilab plans to work towards the ILC cryomodule design after it has experience in building one.

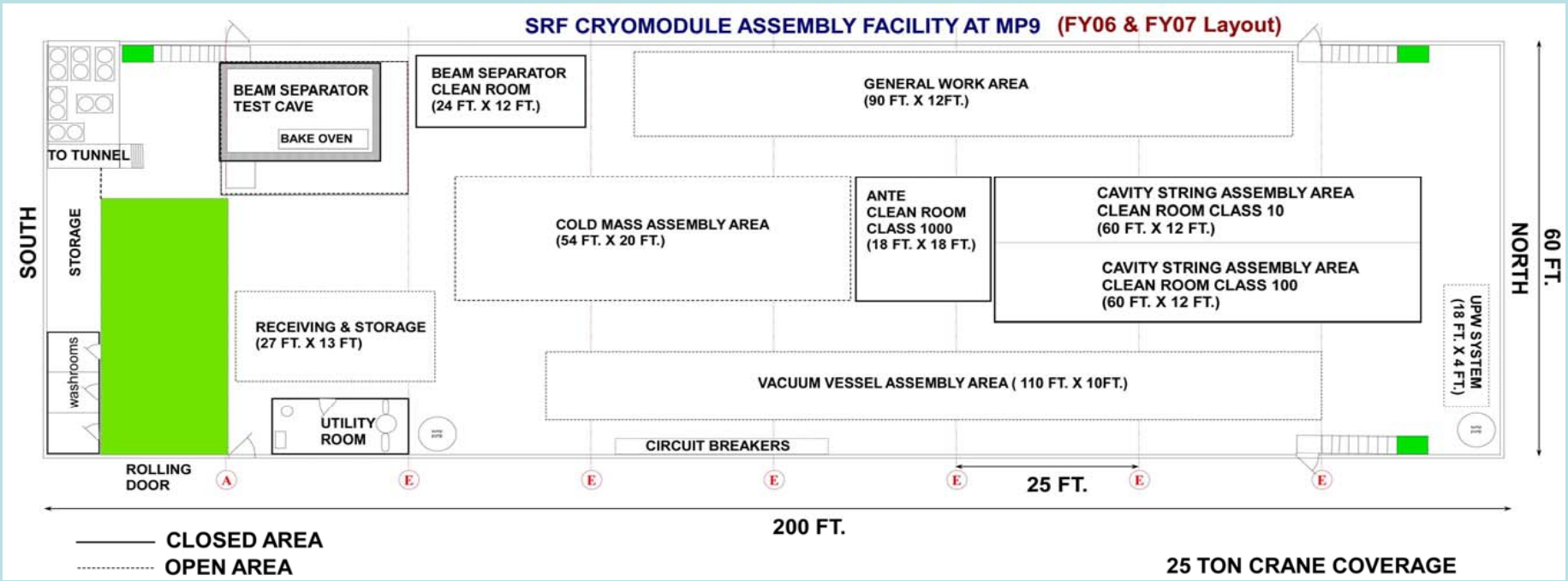
Cryomodule Design and Fabrication

- In FY05 we started on converting the DESY & INFN design of the ILC cryomodule in the US system.
- This work is almost complete and we are in position to order parts for a cryomodule fabrication using the 20 cavities we expect to have by mid FY06.
- The cryomodule is the significant cost in the Main Linac. Industrial fabrication and cost reduction are important issues that we are starting now.
- Fermilab with its considerable experience in assembling large object can help improve the design and fabrication of ILC cryomodule design.
- It is important that we put together a cryomodule and gain valuable experience.

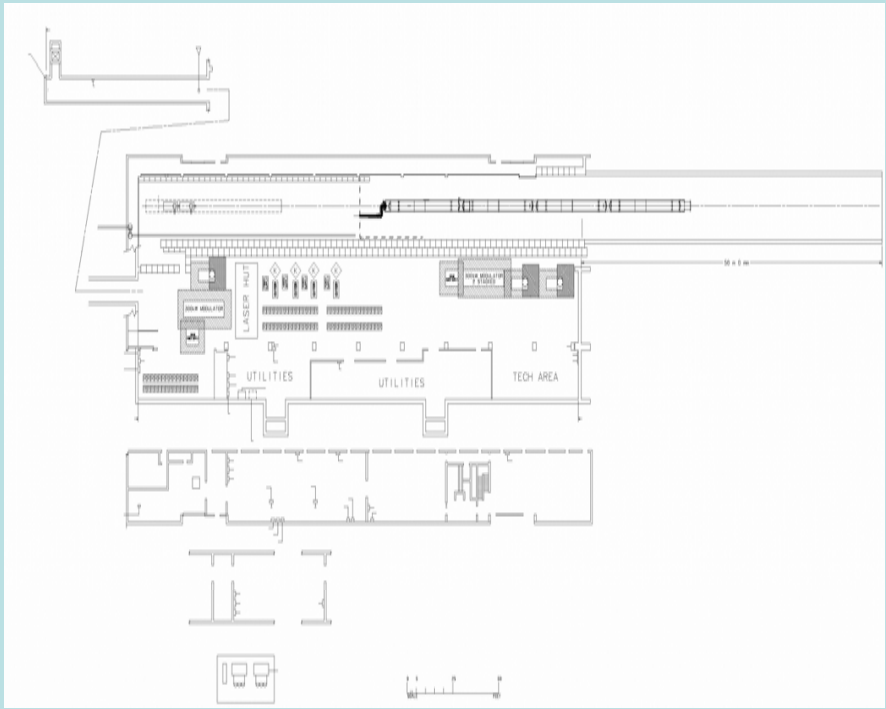
Deliverable: ILC Cryomodule design.

Cavity Testing And Cryomodule Fabrication

- Cavity is produced, processed and vertically tested at SMTF collaborating institutions and start-up US industries.
- Cavity is horizontally tested at Fermilab (Meson/IB1) and assembled into a string at MP9.
- Cryomodule fabrication takes place at MP9.
- Single cryomodule will be tested at the HPTF (New Muon Laboratory).

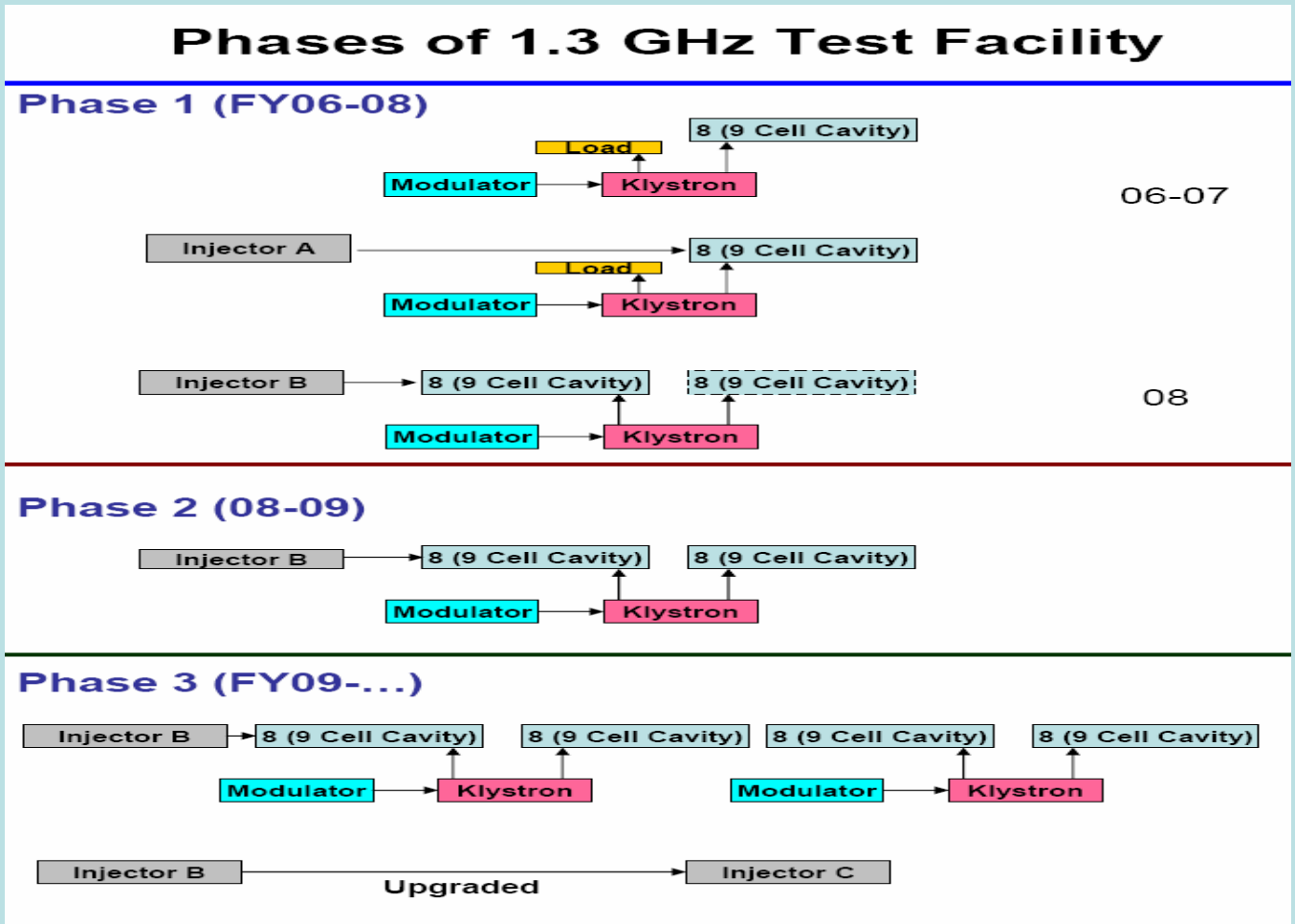


ILC Cryomodule Beam Testing at The New Muon Lab



- There is a new plan of setting up ILC test area in the New Muon Lab and it will require some civil construction.
- This enables us to setup a single cryomodule test area in Meson and have enough room.
- The plan is being developed and will be described by Peter Limon.

Proposed ILC Cryomodule Fabrication and Beam Test at Schedule



Year	Cryomodule Number
06	1
07	2
08	3
09	4-5
10	5-6

We are expecting that 4/6 will reach design gradient.

Deliverable: Fully tested basic building blocks of the Main ILC Linac.
Evaluate the reliability issues. Finalize design choices with GDE (FY09)

RF Power, Controls and LLRF System

- Two modulators are being built at Fermilab. Klystrons will be purchased from Industry.
- DESY prototype FPGA LLRF controller has been installed and tested at Fermilab.
- Fermilab is designing and building a low noise master oscillator for the LLRF system.
- We are developing control algorithms and state control software.
- System design will include: Multiple cavities per klystron operation and Piezo tuner control
- SMTF is collaborating with DESY on LLRF developments and beam studies at TTF.
- We have also discussed with KEK that we should develop a common LLRF and control system (EPICS) for the SMTF and STF

Deliverable: RF Controls and LLRF System for ILC (DESY, FNAL, KEK)

Technology Transfer: Industry

- In a MOU between Fermilab-Cornell we are purchasing 1.3 GHz cavities from AES. Several other MOUs between collaborating institutes are in progress.
- The cavities will be fabricated by AES and chemically treated and vertically tested *by AES* using the Cornell facility.
- So far there is no industry in the world that has learned how to chemically prepare and vertically test the 9-cell cavity.
- These industrial initiatives will not be sufficient for the ILC production needs.
- We need to attract and train large industrial firms to increase the production capabilities by 2010. A industrialization plan is needed for ILC.

Deliverable: Cavity & Cryomodule Technology transfer to Industry.

US Industrial Interaction

- US Industrial base needs to be enhanced in both technology and infrastructure before ILC construction.
- We have started initial industrial contact for the cavity fabrication
  - AES (Small)
  - ACCEL (Mid-Size)
- We are working with local industry in fabricating parts for the cryomodule. (At present plan is to assemble at Fermilab)
- Parson has made a visit to Fermilab to learn about ILC. They expressed interest in learning about cavity and cryomodule fabrication.
- Development of the US Industrial forum for ILC is being discussed. We are planning to hold a workshop for industry.

ILC Deliverables

- Priority 1
  - Cavity technology to routinely achieve ≥35 MV/m and Q ~0.5-1e10.
  - ILC Cryomodule with final design
  - Fully tested basic building blocks of the Main ILC Linac with beam. Evaluate the cost, schedule and reliability issues. Finalize design choices in collaboration with GDE.
- Priority 2
  - RF controls and LLRF System for ILC
  - Instrumentation Development
  - Enhance interaction with industry and Cavity & Cryomodule Technology transfer to Industry.
- Priority 3
  - Production Testing: US Manufacturing development and testing center
  - High gradient cavity development
    - Reentrant and Low Loss Cavity
    - Single Crystal Cavity
  - 3.9 GHz accelerating for bunch compressor

Summary

- R&D program will establish US technical capabilities in SCRF required to support a bid to host ILC.
- The strategic approach of cavity and cryomodule fabrication is sound. It uses the expertise of the collaborating institutions.
- SMTF has well defined deliverables for ILC.
- ILC needs to develop an Industrial plan.